# Development of ECR Ion Source VENUS for the RIA Driver Linac


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## Content

- Introduction
- VENUS Project Milestones
- Commissioning Results
- Future Goals

## VENUS Team

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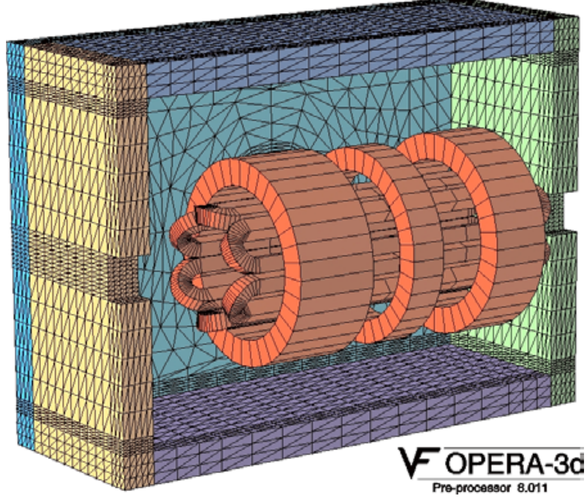
# VENUS Components

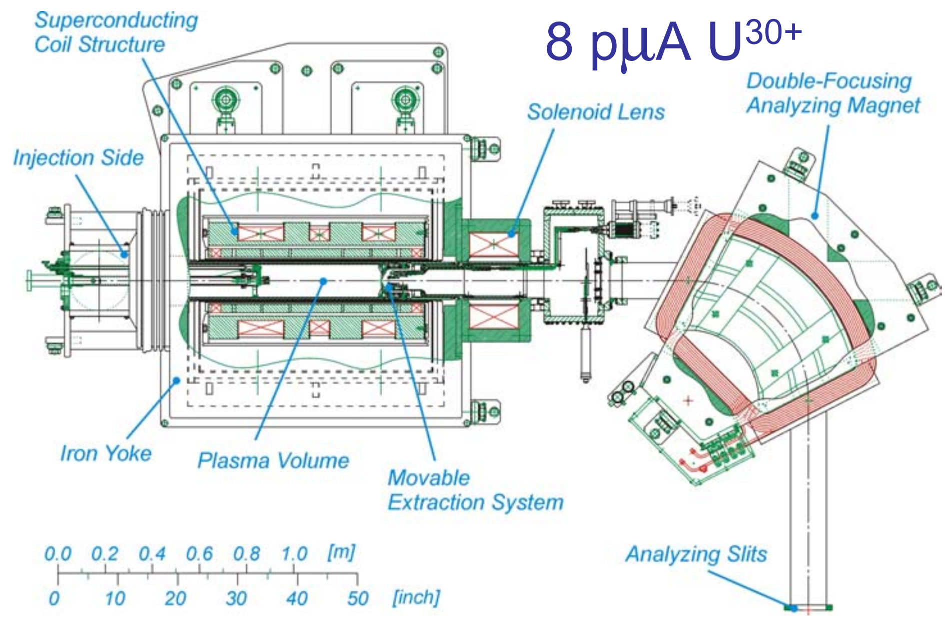
## Superconducting Structure



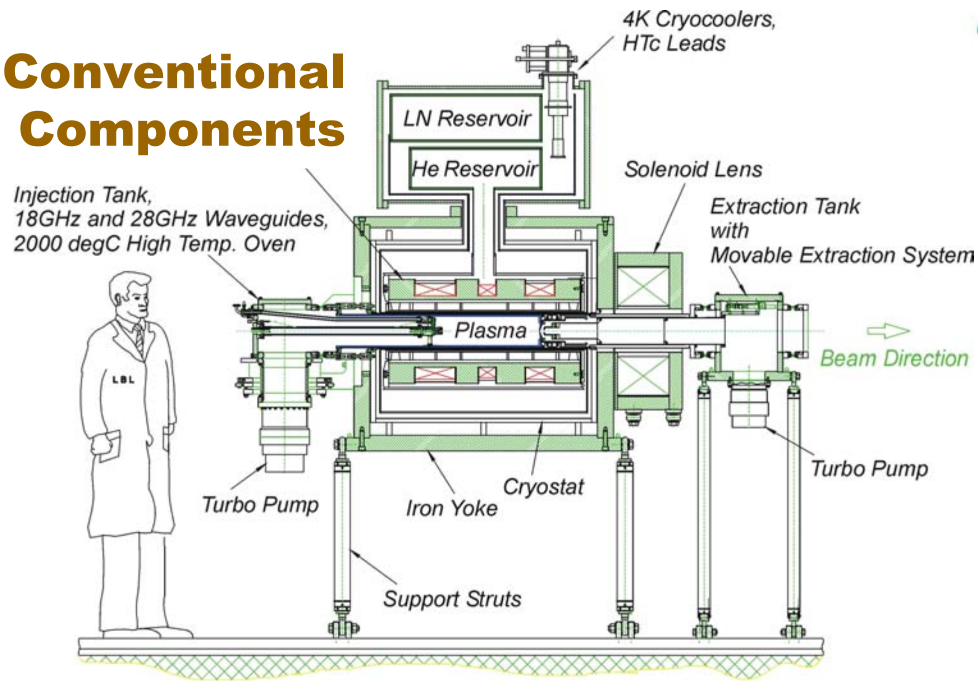

## Beam Transport

RIA R&D Source

8 pμA $U^{30+}$




## Conventional Components

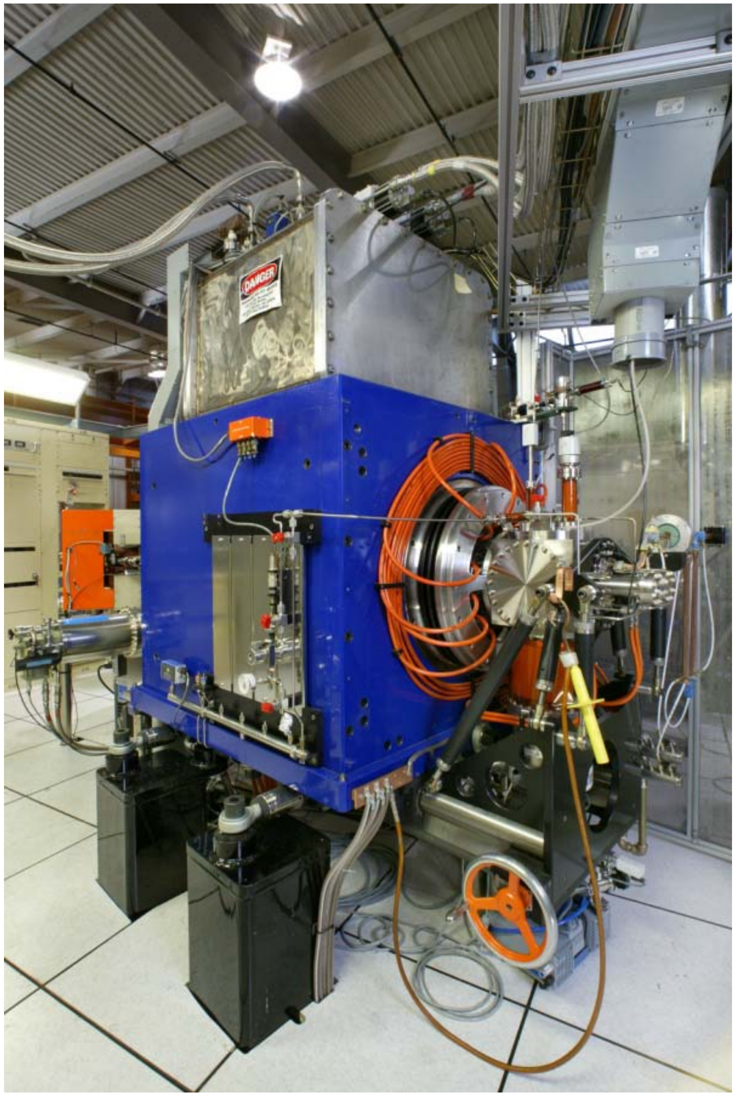



1. **Superconducting magnet structure forces a completely new ion source design, not an extension of an existing design.**
2. **VENUS serves as test bed to understand the transport of high current heavy ion beams**

# VENUS, RIA R&D Milestones

## Magnet & Cryostat

- 4T, 3T, 2.4 T Achieved World Most Powerful ECR Plasma Confinement Structure (September 2001)
- Successful Cryostat Heat Exchanger Redesign (May 2002)
- Power Supply Stabilization for the Superconducting Coils (October 2002)
- Since September 2002 Closed Loop Operation and No Quenches

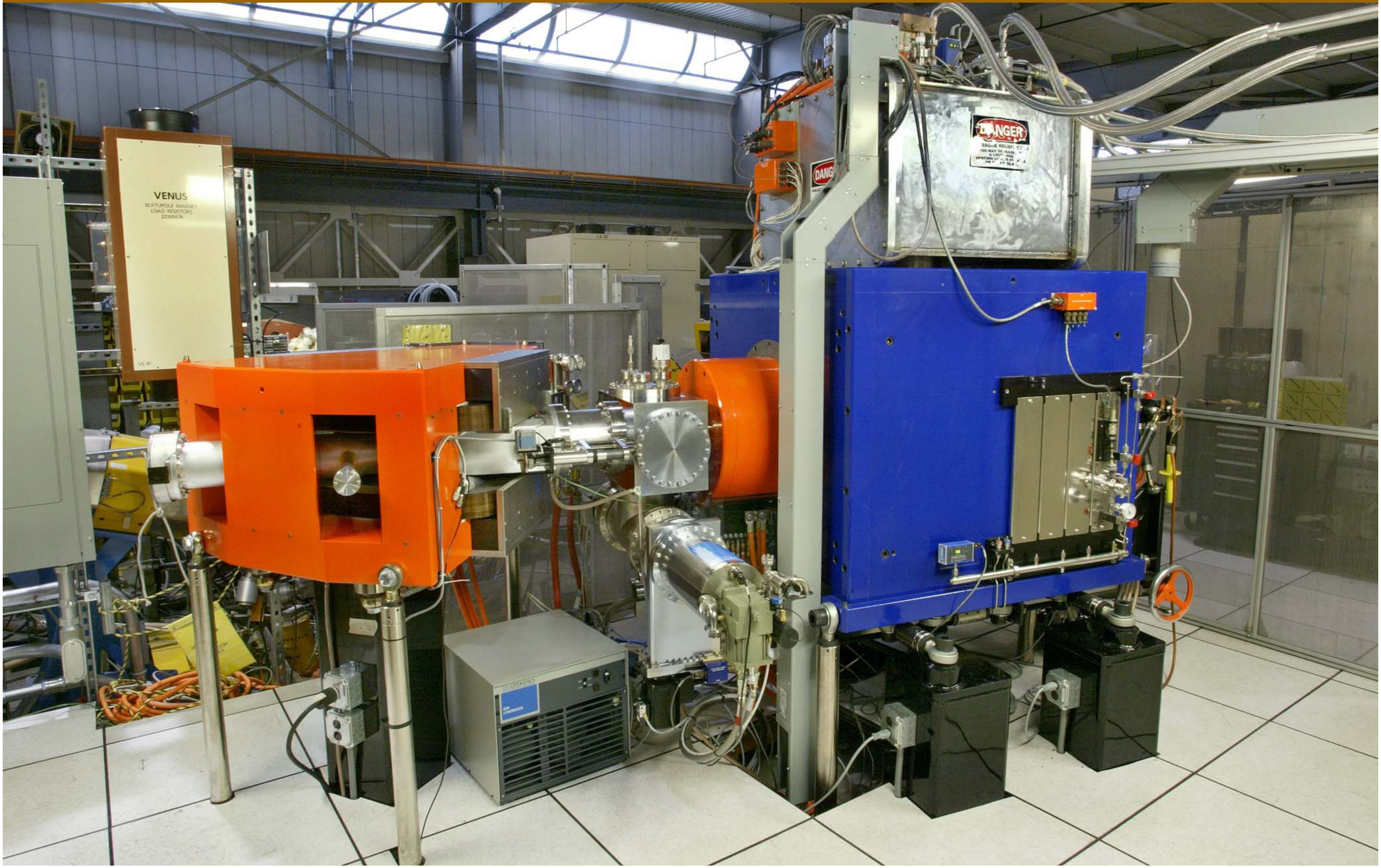


# VENUS, RIA R&D Milestones (cont.)

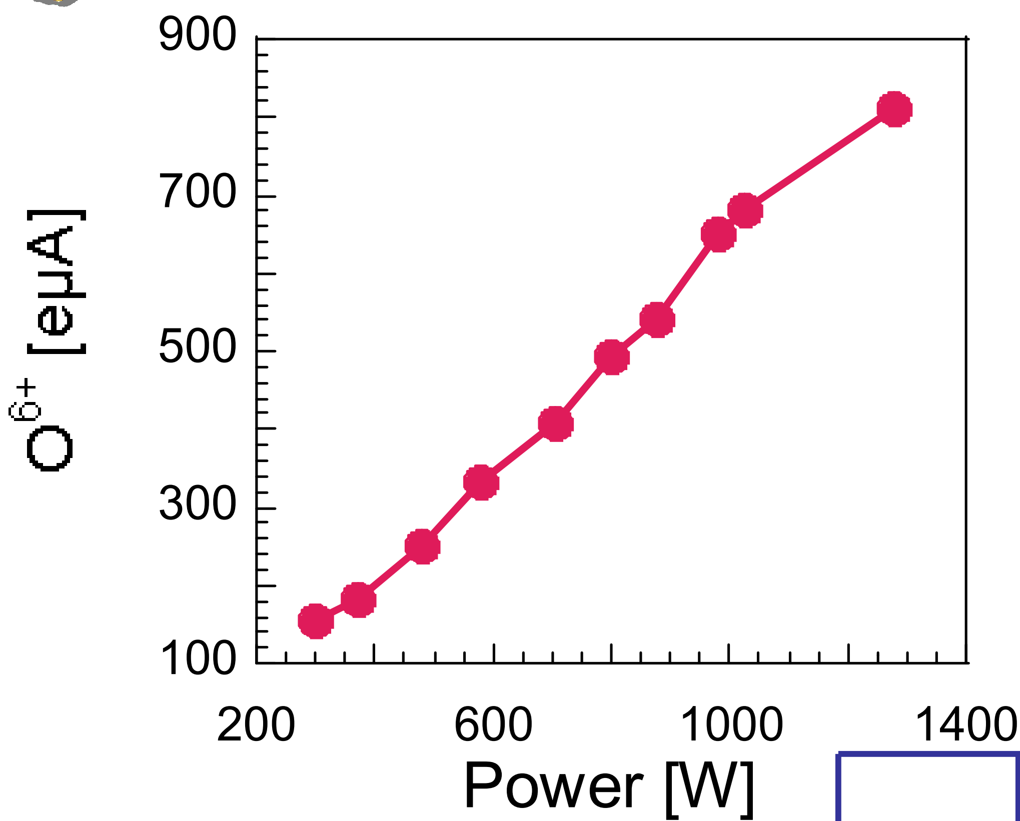
First Plasma 6/6/2002

- First Plasma (June 2002)
- First Analyzed Beam (September 02)
- High Power Coupling at 18 GHz (March 2003)
- First Emittance Measurements (April 2003)
- 28 GHz Gyrotron Ordered (April 2003)
- First Metal Ion Beam (August 2003)
- 28 GHz System Design and Construction (December 2003)

# Commissioning Results



# Promising performance in the first commissioning tests



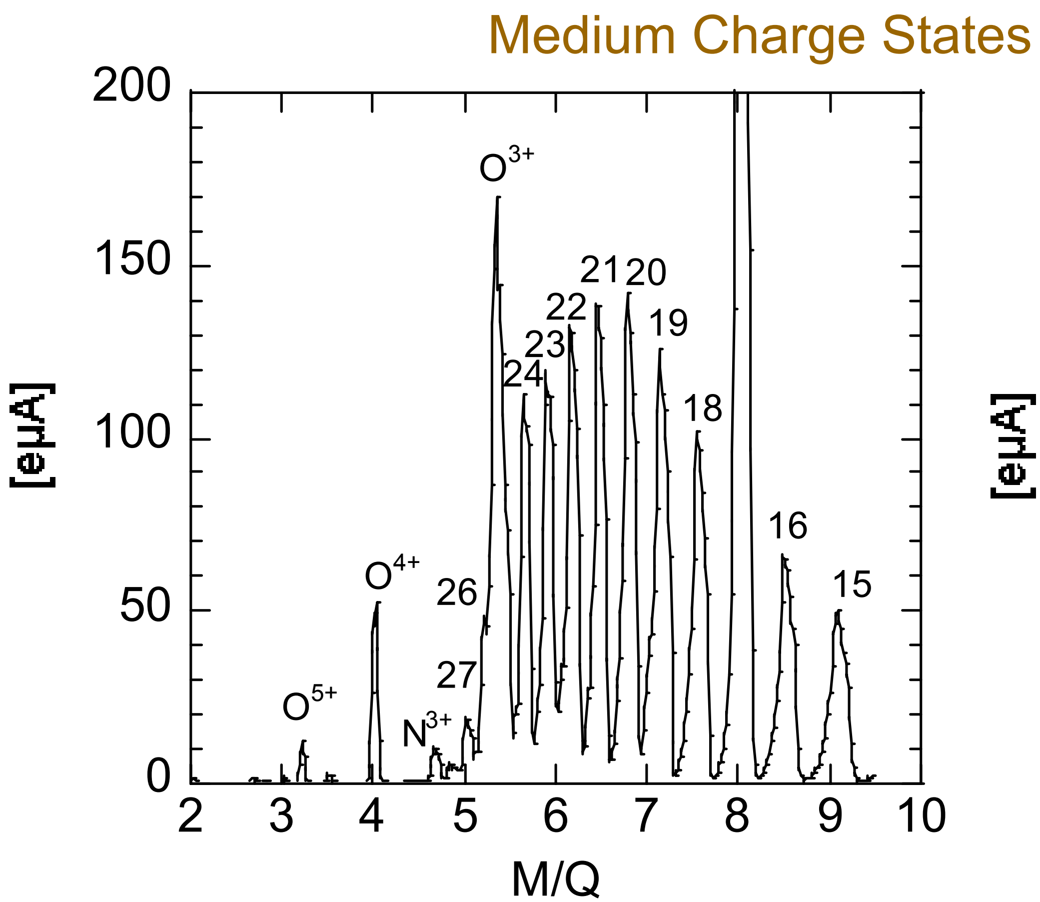

Ion beam intensity increases almost linearly with power at 18 GHz.

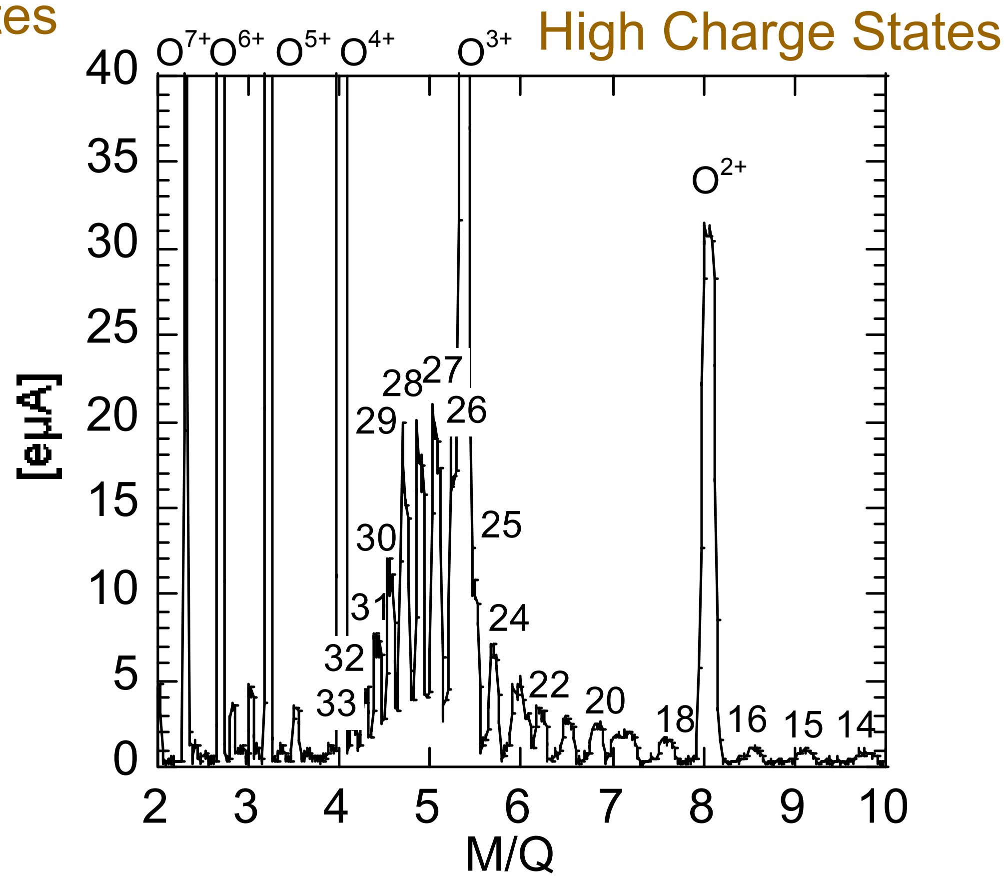
10 kW 28 GHz will be needed to achieve maximum performance

| | AECR-U 10+14 GHz | SERSE 14 +18 GHz | VENUS 18 GHz |
|---|---|---|---|
| $O^{6+}$ | 570 eμA | 540 eμA | 1100 eμA |
| $O^{7+}$ | 300 eμA | 225 eμA | 324 eμA |
| $Ar^{11+}$ | 270 eμA | 260 eμA | 290 eμA |
| $Ar^{12+}$ | 192 eμA | 200 eμA | 180 eμA |

- Operation very reliable and stable
- Fast turn around after venting

# 8 pμA $Xe^{20+}$

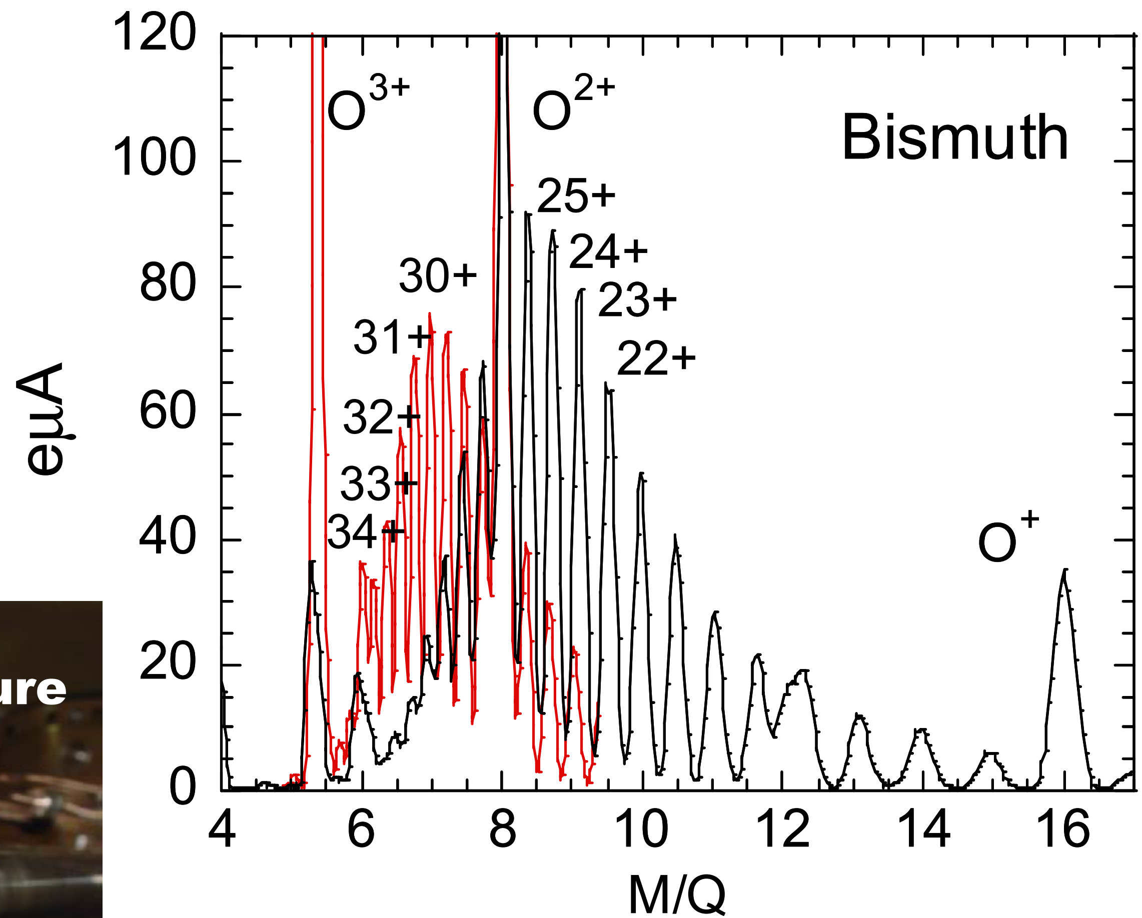


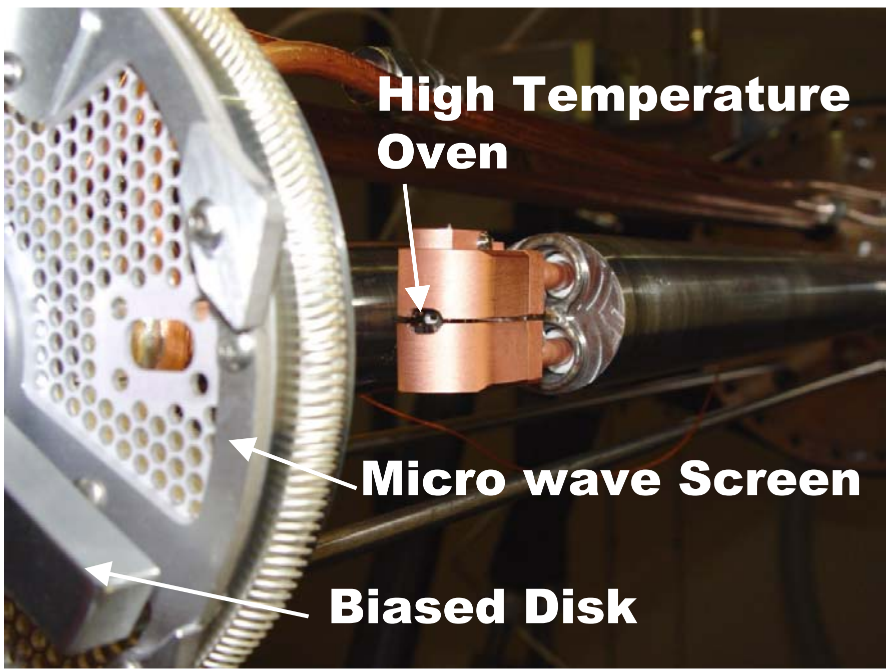




| | AECR-U 10+14 GHz | SERSE 14 +18 GHz | VENUS 18 GHz |
|---|---|---|---|
| $Xe^{20+}$ | | 135eμA | 164eμA |
| $Xe^{27+}$ | 30eμA | 78eμA | 84eμA |
| $Xe^{30+}$ | 12eμA | 38eμA | 28eμA |

# First Heavy Metal Ion Beam 4pμA $Bi^{25+}$

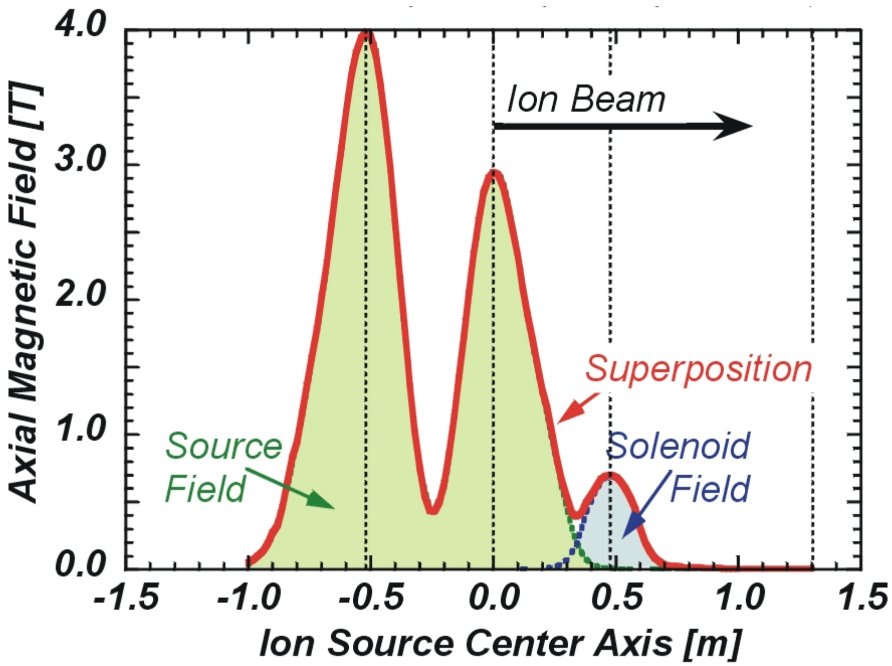
- First Test of the high temperature oven with Bismuth 8/20/03

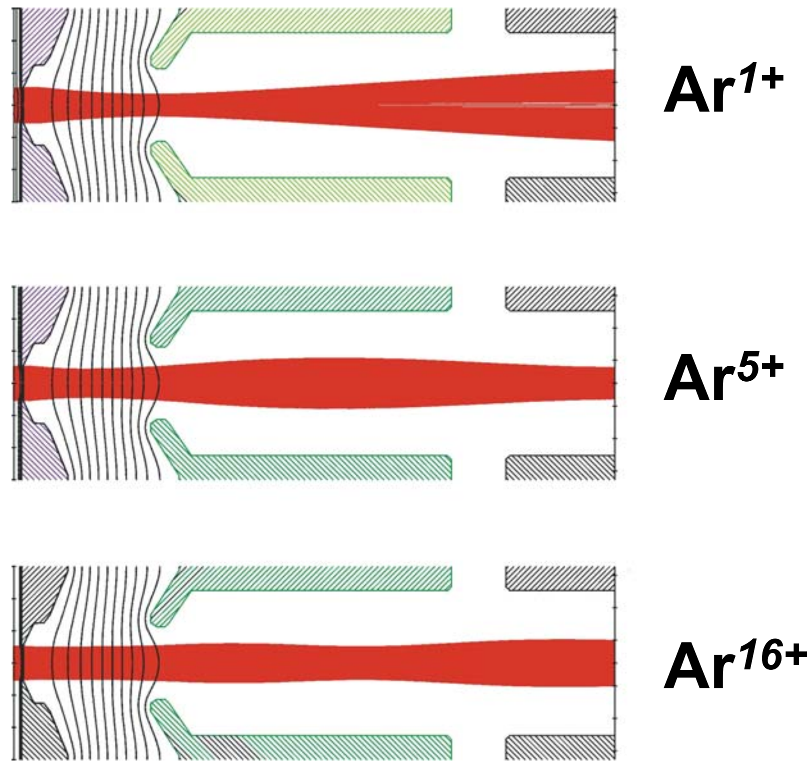



| | AECR-U 10+14 GHz | VENUS 18 GHz First tests |
|---|---|---|
| $Bi^{25+}$ | 70eμA | 100eμA |
| $Bi^{30+}$ | 57eμA | 75eμA |
| $Bi^{34+}$ | 25eμA | 34eμA |

# VENUS Beam Transport

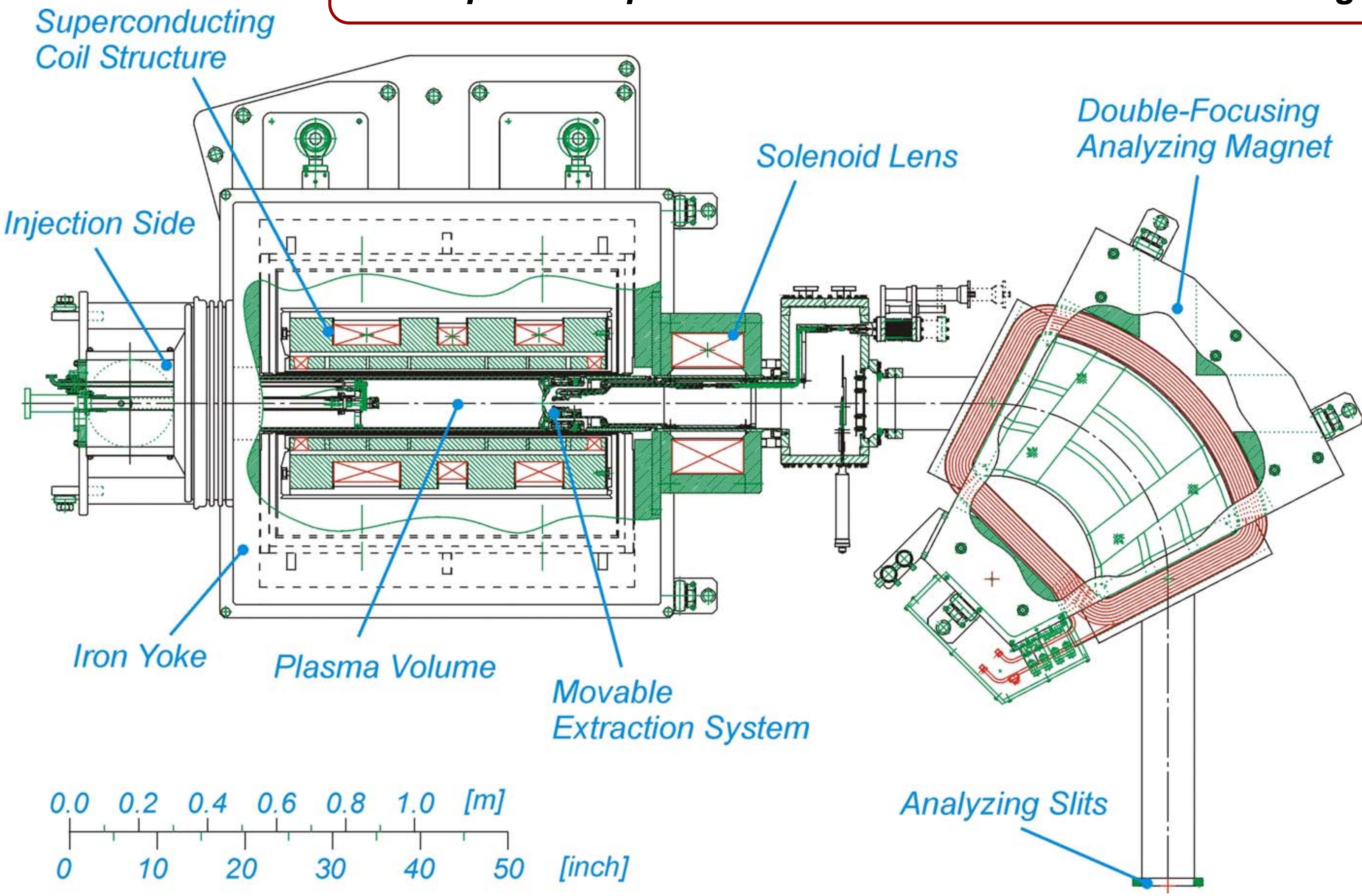


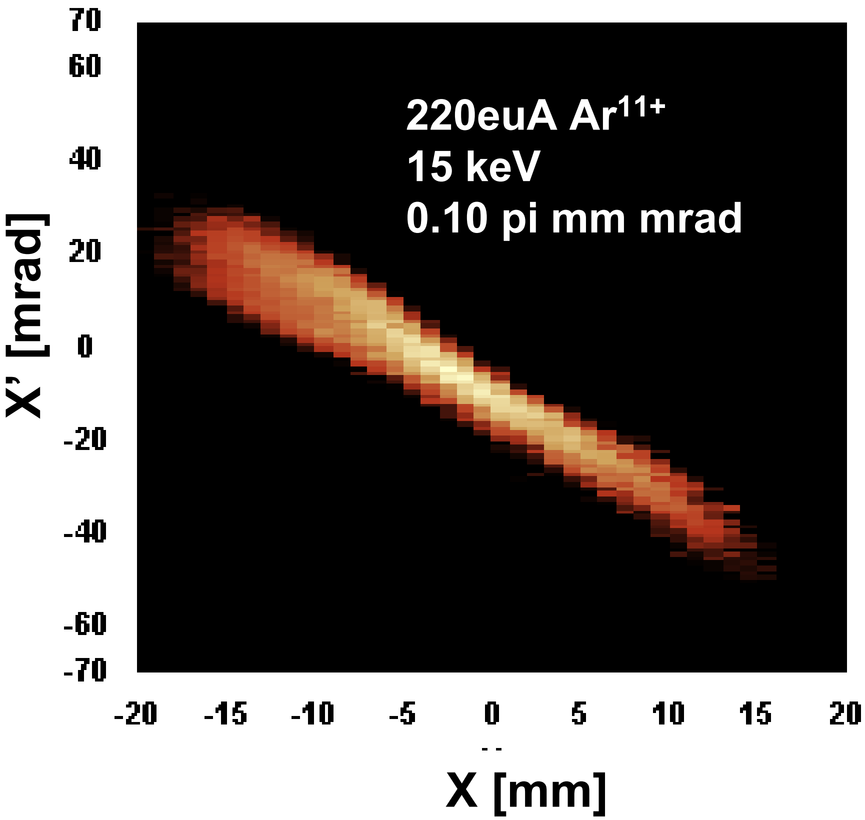

- Space charge dominated beams
- Charge state distribution for each species present at extraction (each contribution must be taken into account correctly)
- Different focusing properties for each M/Q
- Emittance contribution due to the high solenoid field at the extraction

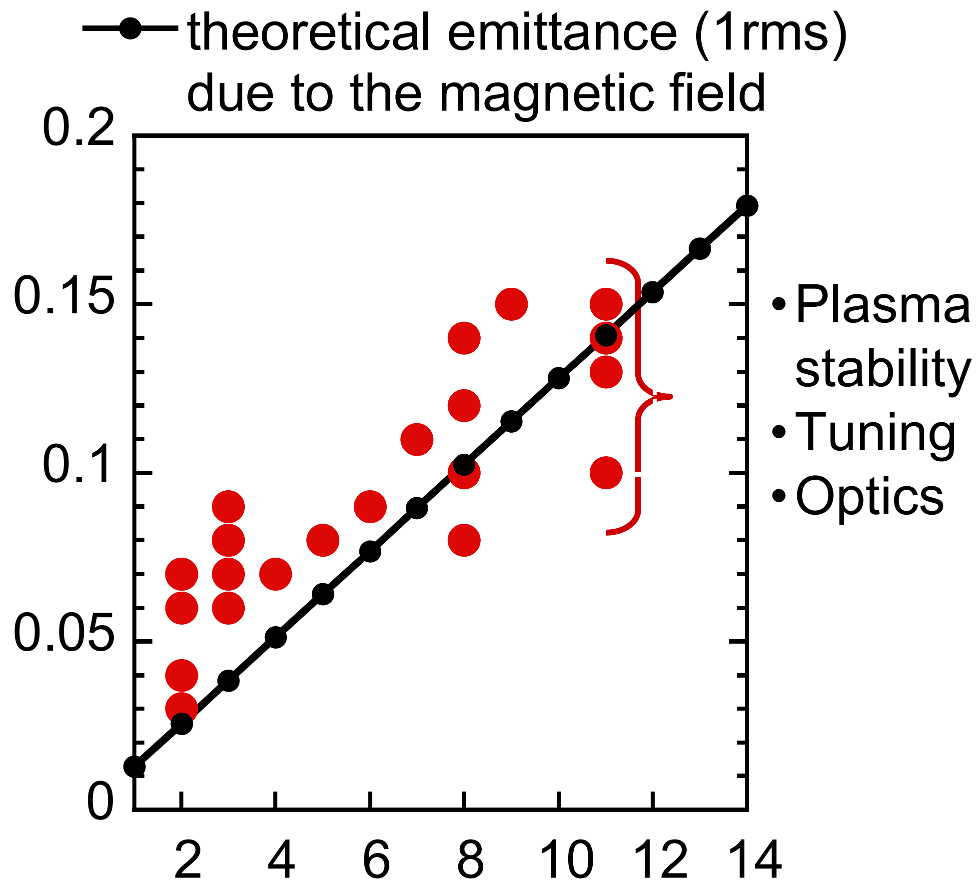
# VENUS Low Energy Beam Transport

***LEBT-Design***
***25 mA proton-equivalent current at 30 kV extraction voltage***



# Argon Emittance Measurements

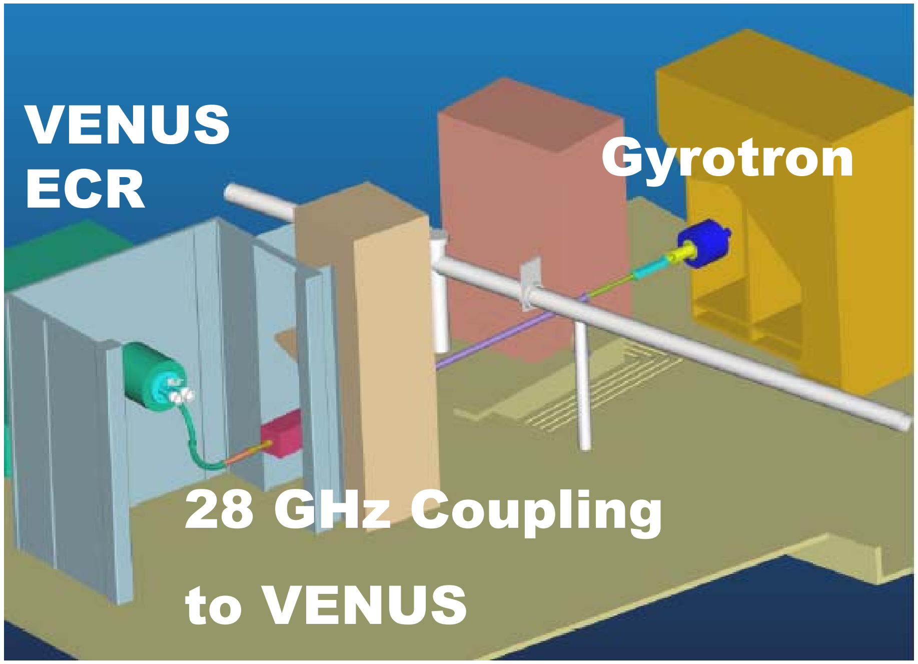



**Essential for**

- Understanding the transport properties of high field ECR ion sources
- Developing the simulation tools for the next generation heavy ion beam injectors (RIA, LHC, RIKEN)

# 28 GHz Coupling into VENUS




- High intensity RIA beams are only possible at 28 GHz
- 28 GHz 10 kW Gyrotron system has been ordered (April 2003)

- Timeline
  - Modification of the Cryostat (September 2003)
  - Delivery of the Gyrotron (December 2003)
  - Start commissioning at 28 GHz (Spring 2004)

# Summary & Future RIA R&D

**FY03**

- Commissioning at 18 GHz
- Procurement, Design and Construction of 28 GHz Components

→

**Achieved FY03:**

- VENUS running closed loop (11month+)
- 180pμA $O^{6+}$, 8pμA $Xe^{20+}$
- First High Temperature oven test 4pμA $Bi^{25+}$
- First emittance measurements

**FY04-05**

- High power 28 GHz coupling into VENUS
- Commissioning at 28 GHz

→

- Systematic Tuning
- Emittance measurements and ion beam transport simulation (integrated modeling)
- Optimizing for high intensity heavy ion beams for RIA (first uranium test)

**FY05-06**

- Systematic Measurements for RIA Driver beams
- Charge Breeder ($0^+, 1^+ \rightarrow n^+$)

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- RIA Driver Front End Development
  - Systematic Driver Beam Development
- RIA Post Accelerator Development